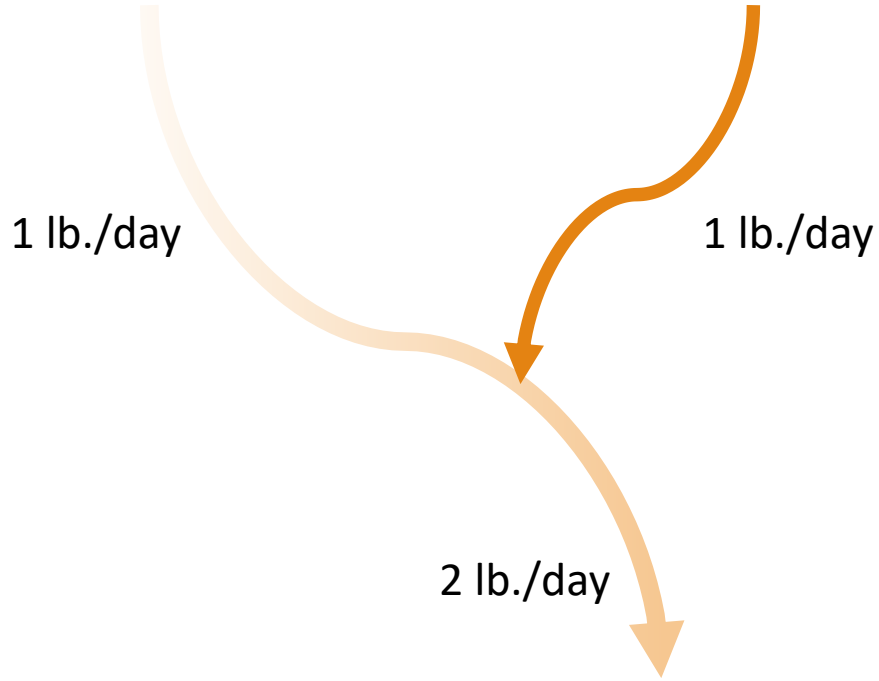
Metals Loading 101

- Metals are measured in water as a concentration
- The rate at which metals enter surface water depends on the flow and is called a load or loading rate

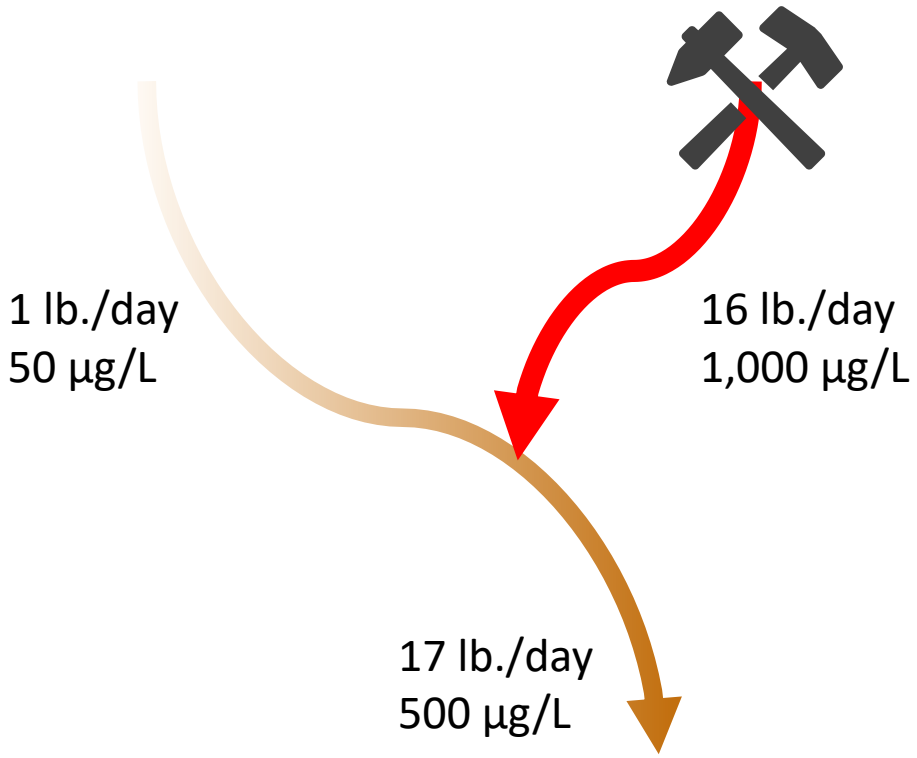
Concentration x Flow = Load (*in pounds of metal / day*)

- A high concentration of metals with a low flow rate results in a small load and has little impact on surface water
- A moderate concentration of metals with a high flow rate results in a large load and has a significant impact on surface water

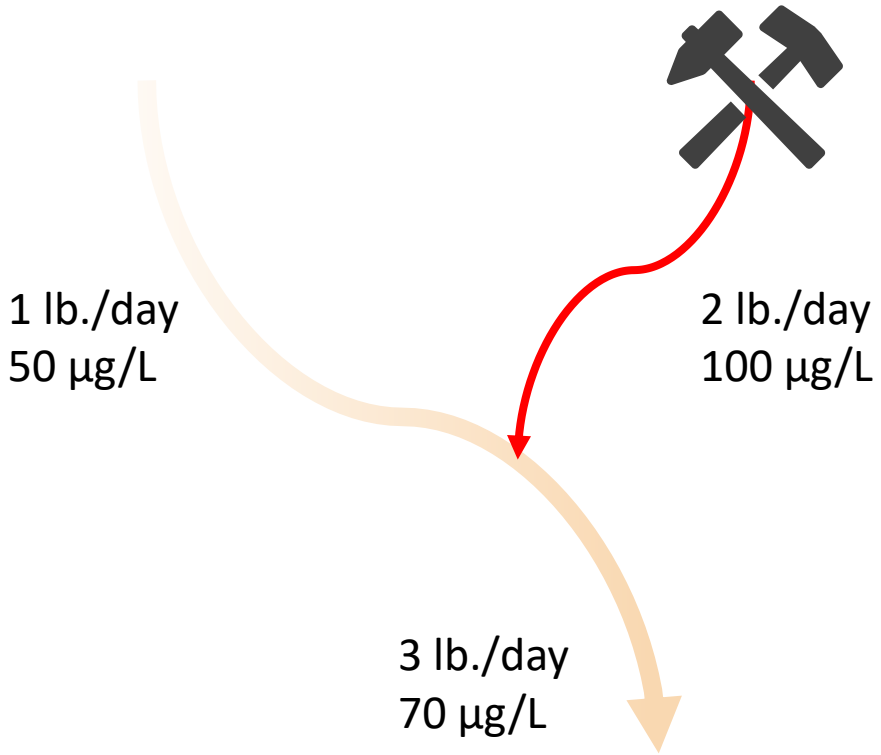
Conservative Metals Loading Analysis



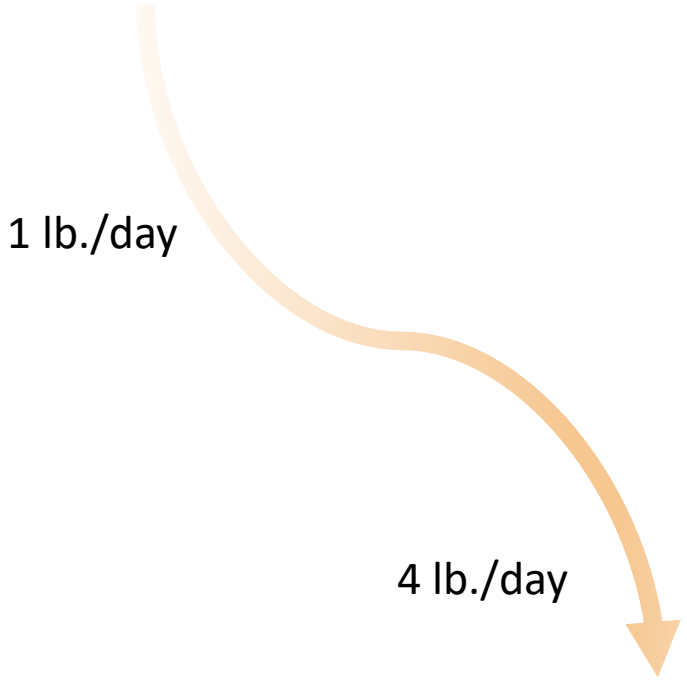
Metals Loading Sources



Metals Loading Reduction



Reach Loads

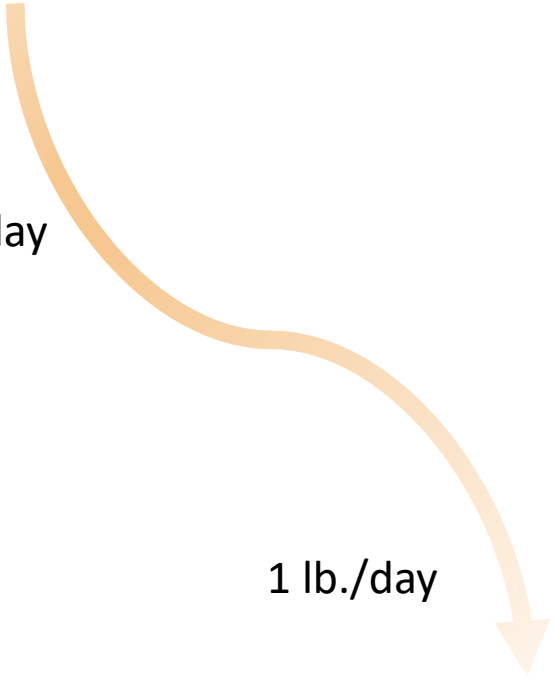


POSITIVE REACH LOAD

Natural Sources

Unmeasured Man-Made Sources

Measurement / Data Error (e.g. bad flow)



NEGATIVE REACH LOAD

Metal Precipitation

Changes in Hydrology (i.e. losing reach)

Measurement / Data Error (e.g. bad flow)

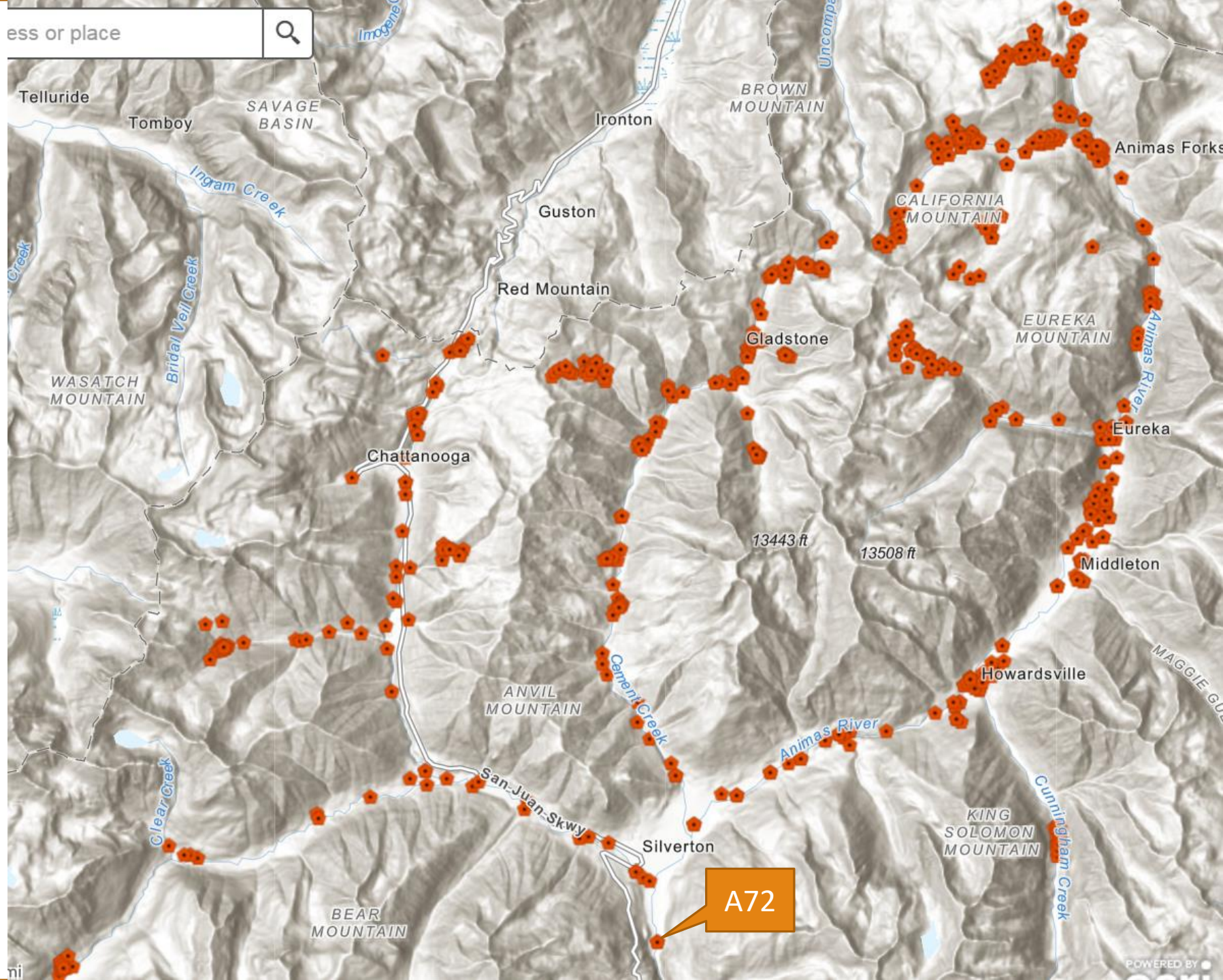
Data

EPA has been collecting data at Bonita Peak since 2010

Thorough coverage for site-wide analysis

Known tributaries, mine sites, and other sources bracketed

Key parameters: Flow, dissolved and total metals, hardness



Major Streams/Rivers

- The major streams and rivers at Bonita Peak are:
  - Animas River
  - Mineral Creek
  - Cement Creek
- Each has tributaries, some are very important source areas
- Analysis of flow data show flows are lowest at headwaters and increase downstream as expected
- **Station A72 includes all tributaries and is an important station (Station 0.0)**

Source Cleanup and Resulting Water Quality Improvements

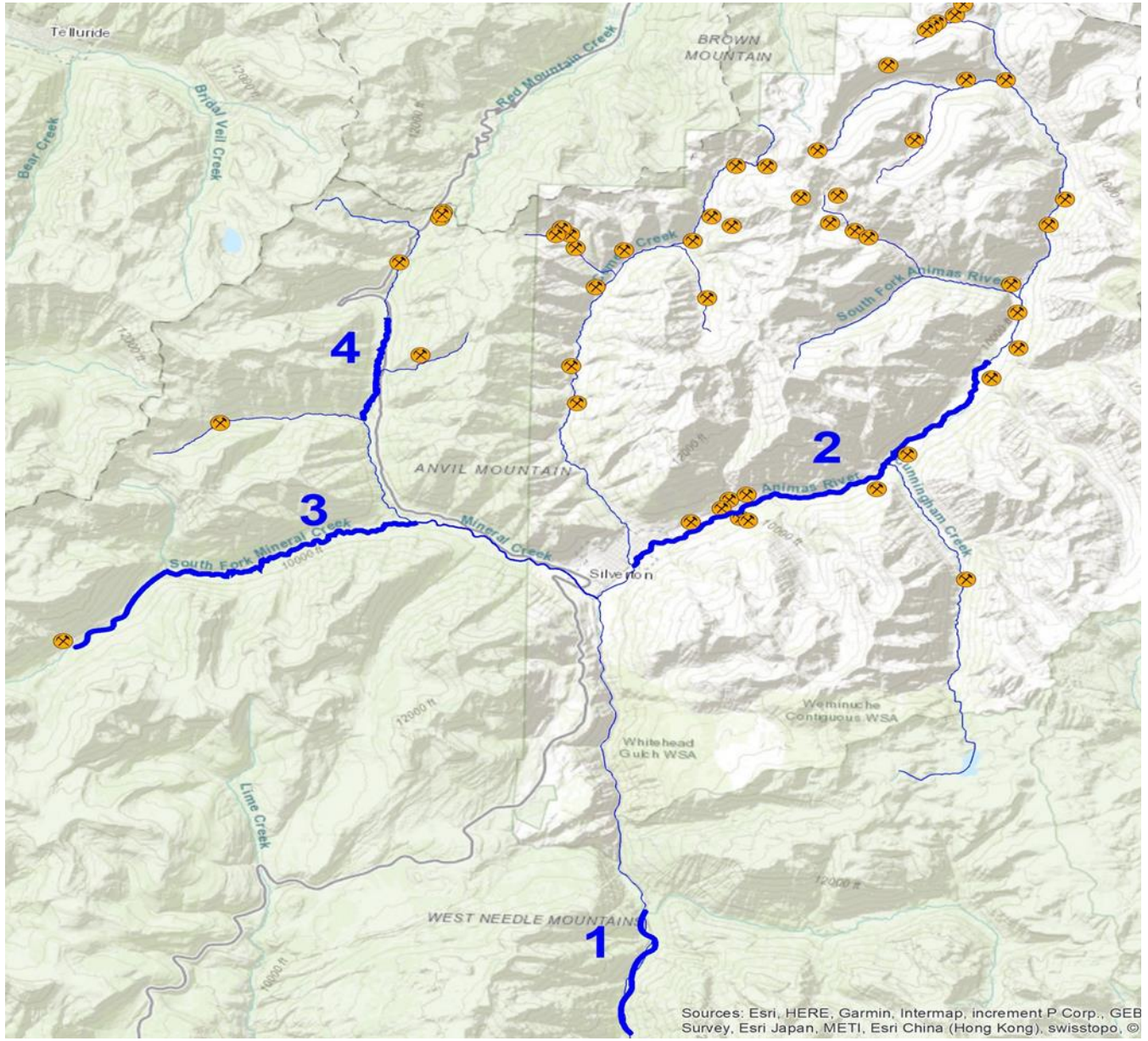
- With all of the measured sources and unmeasured reach loads tabulated, it is now possible to evaluate the relative impact of addressing individual mine site sources
- Some sources can be greatly reduced such as collection and treatment in a water treatment plant (nearly 100% reduction)
- Other sources are remote or more difficult to obtain reductions (maybe 50%)
- A menu panel has been developed to evaluate the effects of various source load reductions
- Once loading calculations are complete, metal concentrations are back-calculated

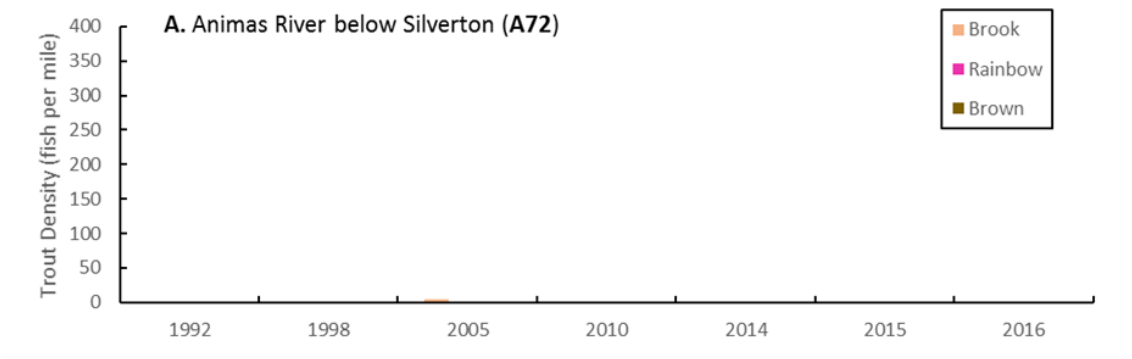
Current Limitations of the Loading Tool

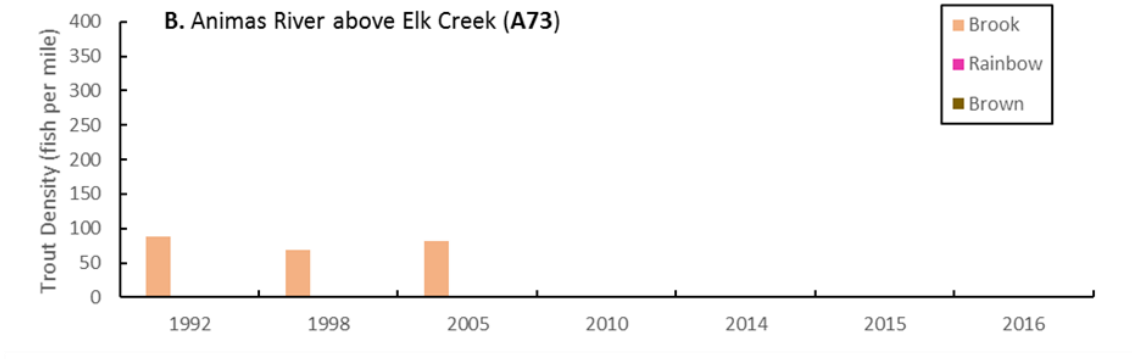
- Uncertainty in the measurements (flow and concentration)
- Variability in the availability of data (some locations are measured only once while others more often)
- Applicable only to generally conservatively transported metals/ions
  - Conservative Metals of Concern: Zinc, cadmium, manganese
  - Reactive Metals of Concern: Lead, copper, aluminum, iron
- Negative reach loads
- 2018 low flow data not included
- Tool is limited to low flow period

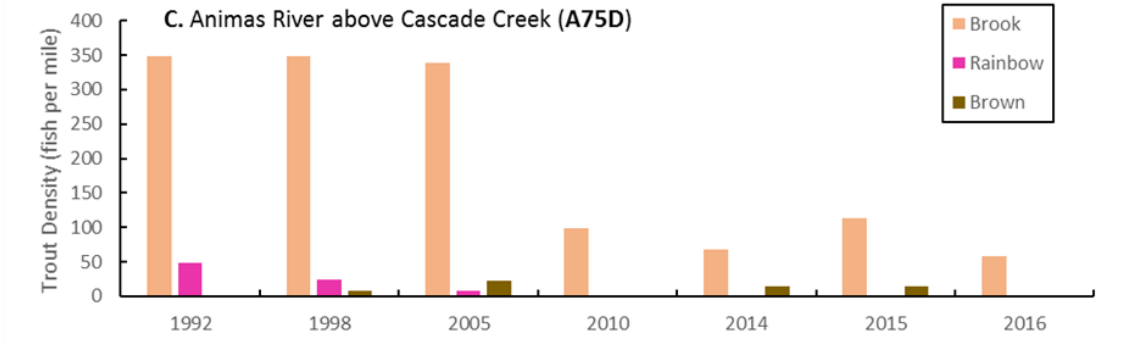
Priority 1

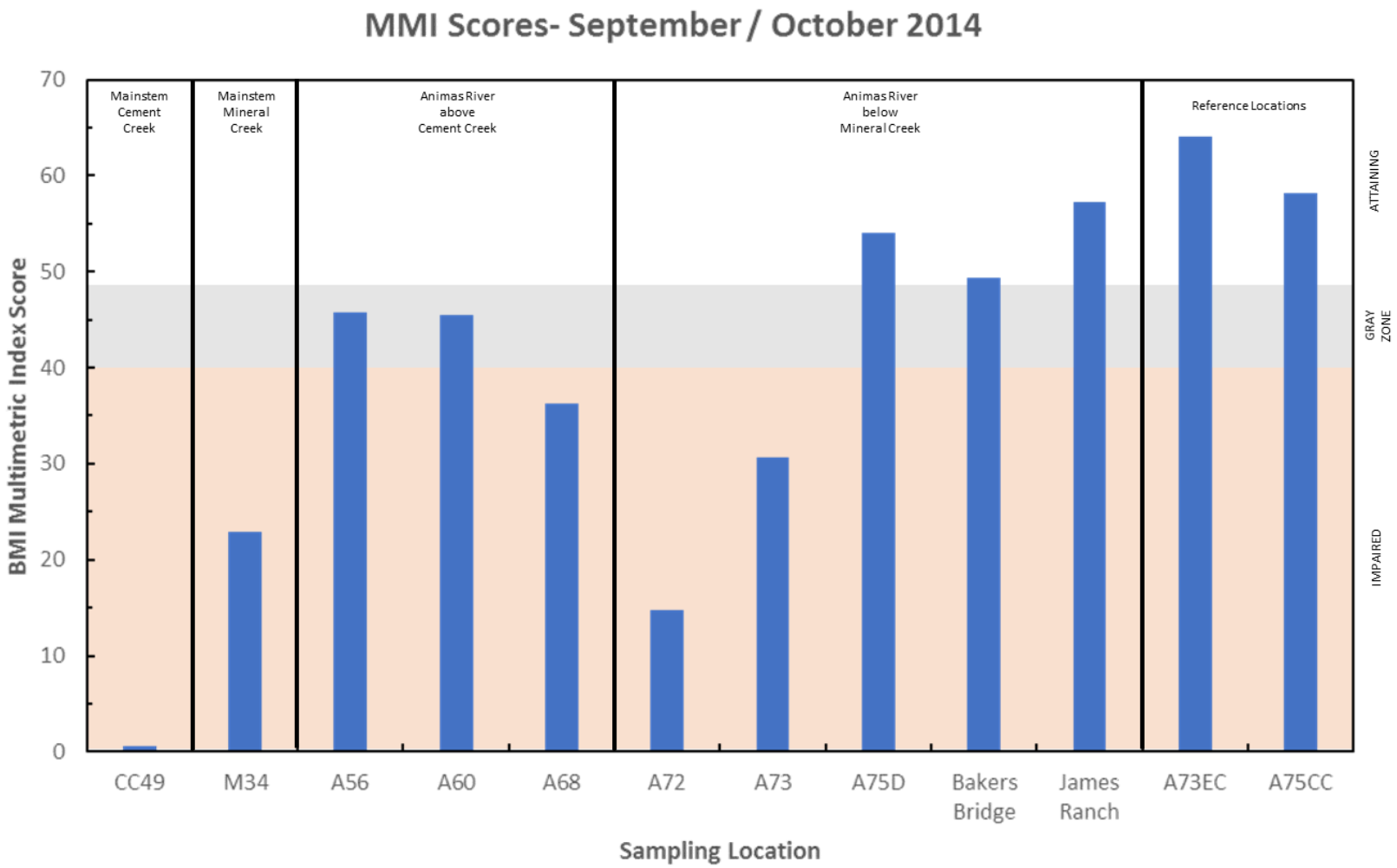
- Animas from Elk Creek to Bakers Bridge
- Many metal loading mines remain
  - All BPMD mines
  - Including Cement Creek
- Fishery has been marginal in this reach for a while
  - Diversity and abundance increase moving downstream
  - Fishery was impacted when treatment plant went offline in 2005




A. Animas River below Silverton (A72)
Trout Density (fish per mile)
400
350
300
250
200
150
100
50
0
1992
1998
2005
2010
2014
2015
2016
Brook
Rainbow
Brown


B. Animas River above Elk Creek (A73)
Trout Density (fish per mile)
400
350
300
250
200
150
100
50
0
1992
1998
2005
2010
2014
2015
2016
Brook
Rainbow
Brown


C. Animas River above Cascade Creek (A75D)
Trout Density (fish per mile)
400
350
300
250
200
150
100
50
0
1992
1998
2005
2010
2014
2015
2016
Brook
Rainbow
Brown


MMI Scores- September / October 2014
BMI Multimetric Index Score
70
60
50
40
30
20
10
0
Mainstem Cement Creek
Mainstem Mineral Creek
Animas River above Cement Creek
Animas River below Mineral Creek
Reference Locations
ATTAINING
GRAY ZONE
IMPAIRED
CC49
M34
A56
A60
A68
A72
A73
A75D
Bakers Bridge
James Ranch
A73EC
A75CC
Sampling Location

Priority 1-Canyon Reach(Cont.)

Goal-Meet TVS (except Al?) in Animas above Elk Creek

- Current WQ Standards
  1. Segment 4a; Animas from Mineral Creek to above Deer Park Creek; *Agriculture, Aq Life Cold 2, Recreation E*.
     - TVS + Seasonal Mod for Al, Fe, pH and Zn and SSE for Cd.
     - Aquatic Life Indicator Goal; Brook Trout
  2. Segment 4b; Deer Park Creek to Bakers Bridge; *Agriculture, Aq Life Cold 1, Recreation E, Water Supply*
     - TVS + temp mod for Arsenic expires 2021.
  3. Chemistry data is limited through the canyon due to remoteness

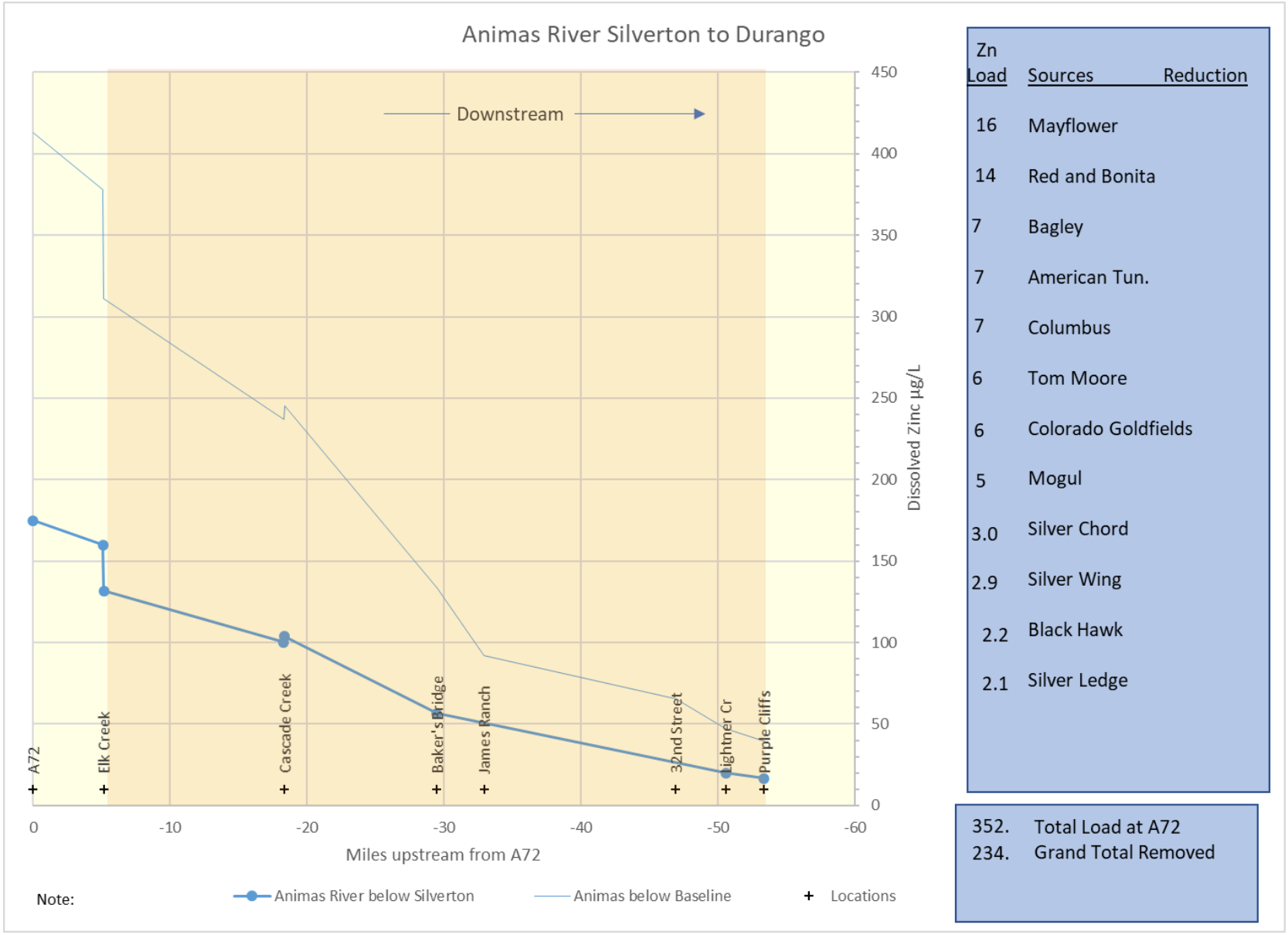
Priority 1-Canyon Reach (cont.)

Goal-Meet TVS (except Al?) in Animas above Elk Creek

- Source Areas
  1. All upstream priority source areas
  2. Cement Creek
     - Red and Bonita (65 lbs/day)
     - Mogul (21.4 lbs/day)
     - Natalie Occ. (10.23 lbs/day)
     - Grand Mogul (7.12 lbs/day)
     - Prospect Gulch (3.07 lbs/day)
     - Other

Priority 1

- Loading reduction of **75%** at all of the mines identified
- Zinc concentrations at Elk Creek predicted to be reduced from ~310 ppb to ~130 ppb
- Poor / fair brook trout population already established in this reach
- Other metals may limit reach in addition to zinc (Al, Fe, Cd)



Zn Load	Sources	Reduction
16	Mayflower	
14	Red and Bonita	
7	Bagley	
7	American Tun.	
7	Columbus	
6	Tom Moore	
6	Colorado Goldfields	
5	Mogul	
3.0	Silver Chord	
2.9	Silver Wing	
2.2	Black Hawk	
2.1	Silver Ledge	

352. Total Load at A72
234. Grand Total Removed

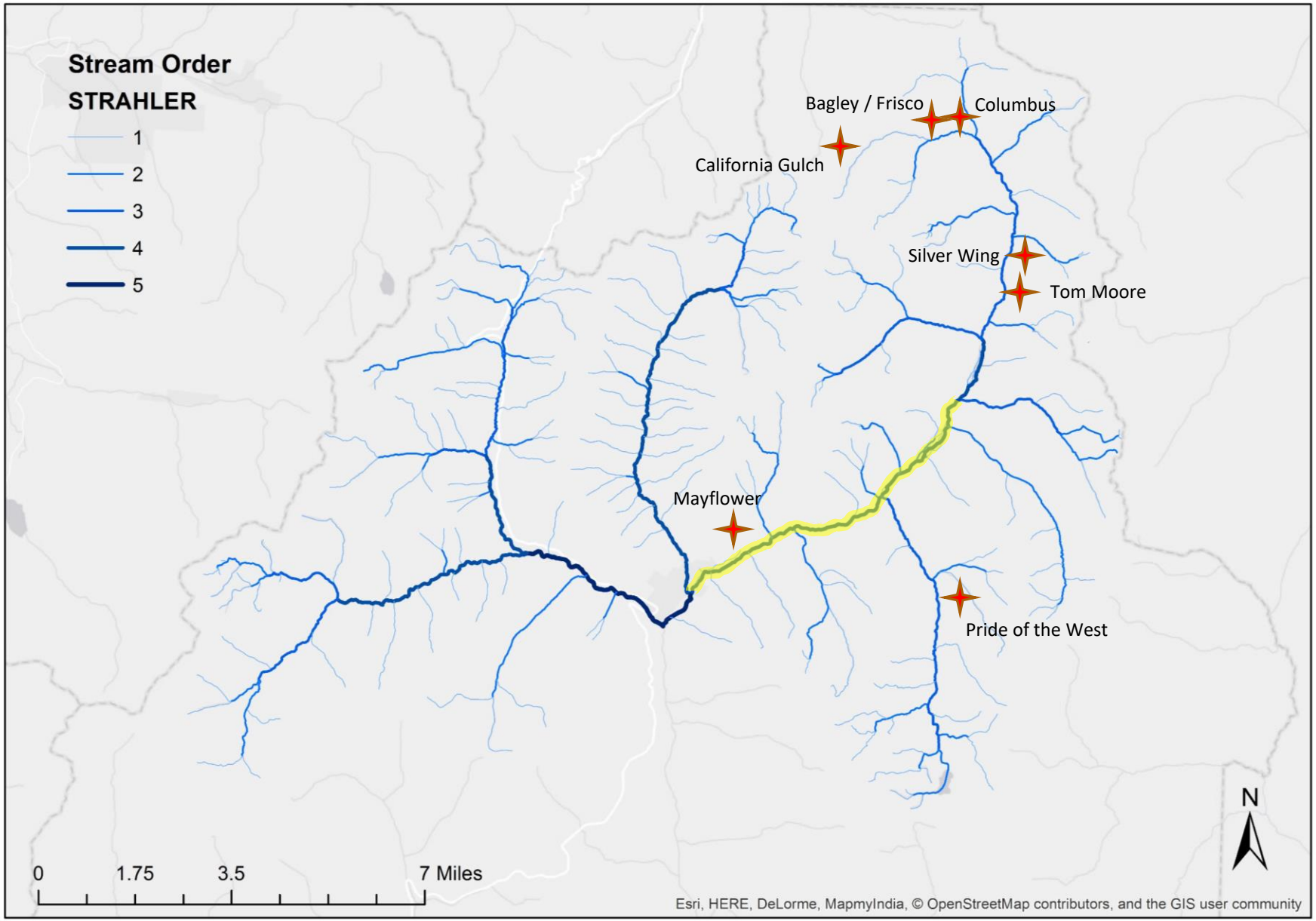
Priority 1-Canyon Reach (cont.)

Goal-Meet TVS (except Al?) in Animas above Elk Creek

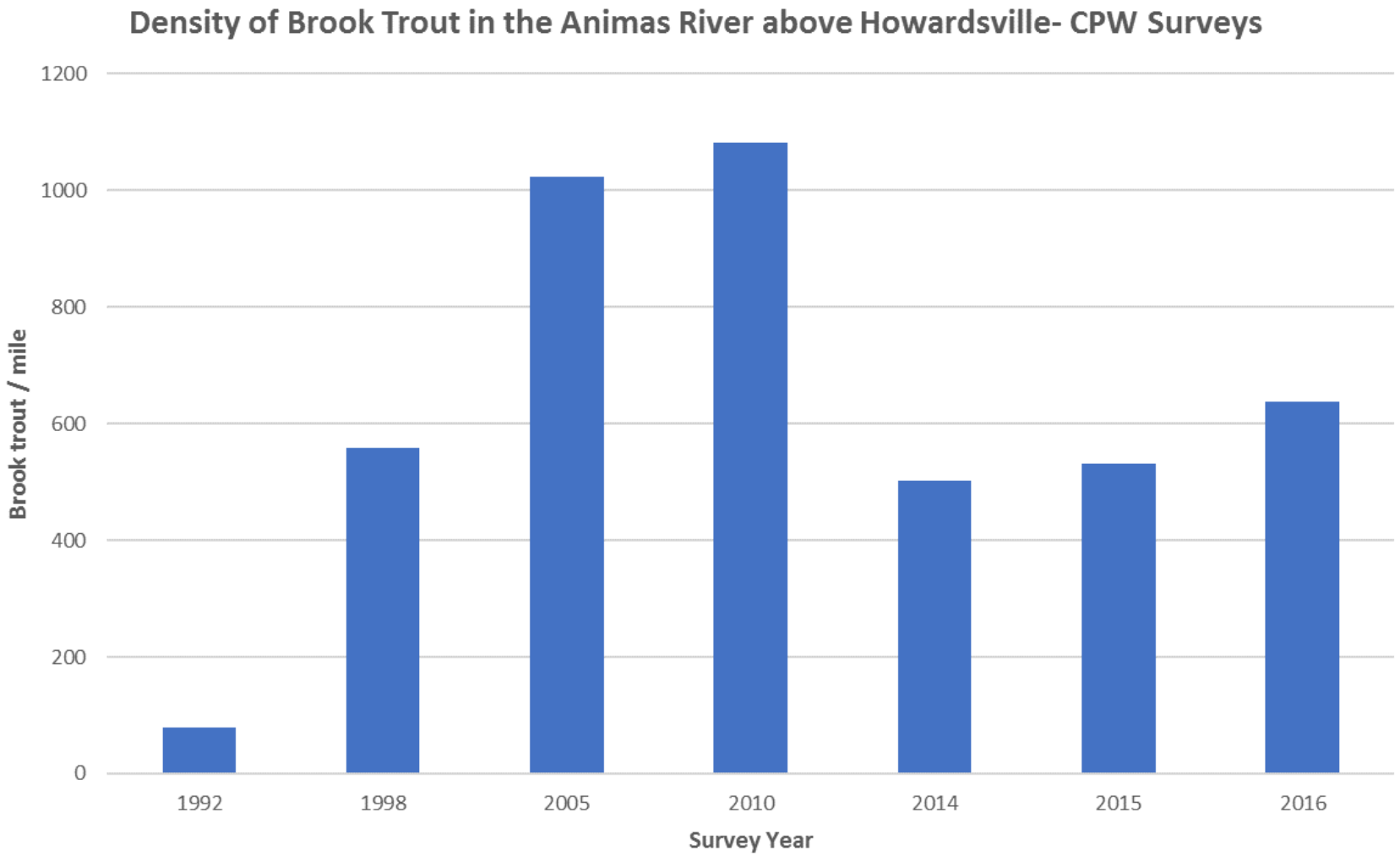
- Data Gaps
  1. Limited data in Canyon reach
  2. Mine Pool
- Background Needs
  1. Mine Pool?
  2. Same considerations for other priority areas.

Priority 2

- Animas from Minnie Gulch to Cement Creek
- Many metal loading mines remain
  - Upper Watershed Sources
  - Silver Wing / Tom Moore
  - Pride of the West
  - Mayflower
- Fishery has been present in this reach for a while
  - Brook trout- stable at top
  - Cutthroat trout- occasional from tributaries



Community Surveys (Fish)



Priority 2-Howardsville Area (Cont.)

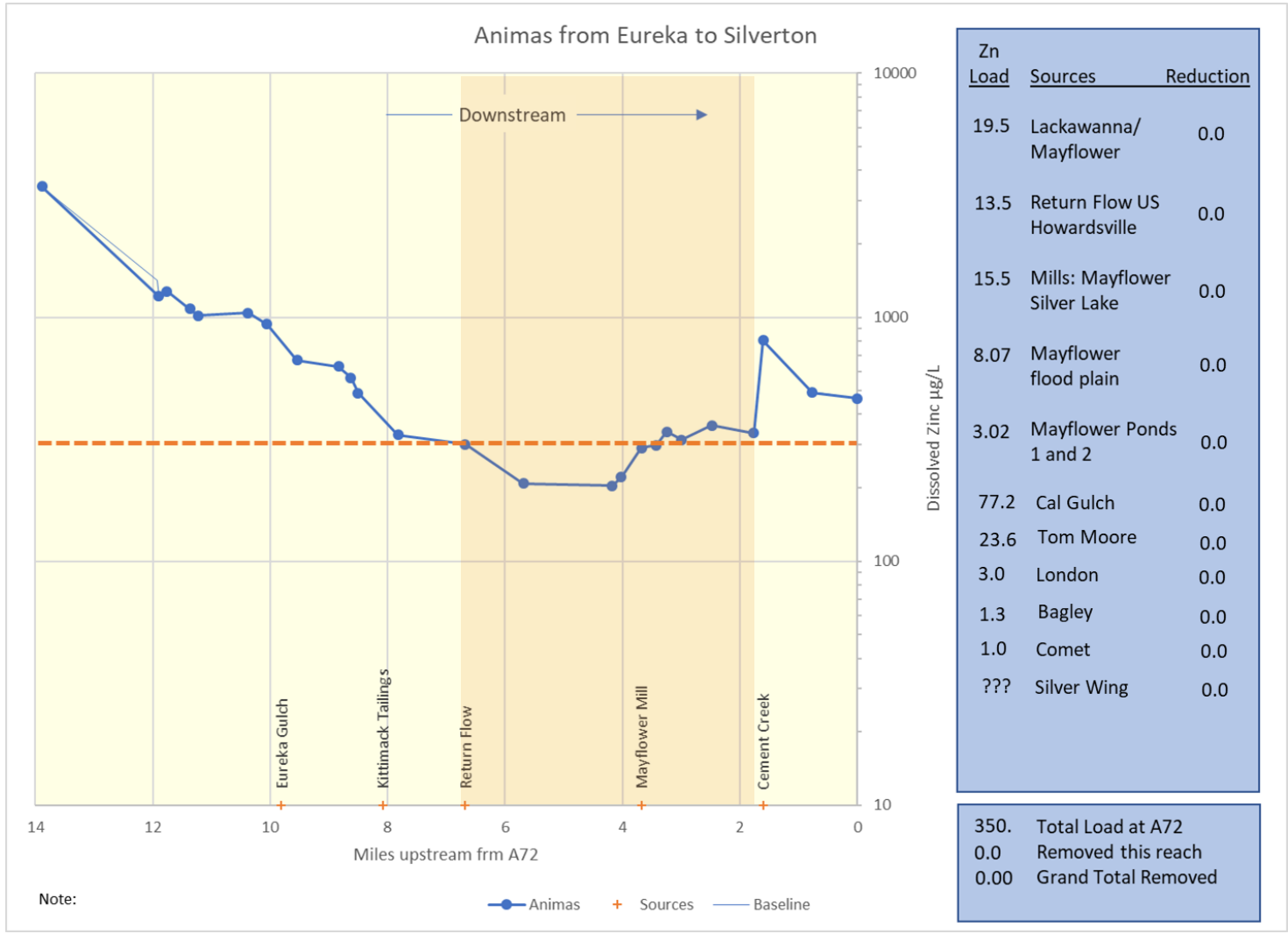
Goal-Improve Water Quality

- Current WQ Standards
  1. Segment 3a; Mainstem of the Animas from Minnie Gulch to Cement Creek; *Agriculture, Aq. Life Cold 1, Recreation E.*
  2. TVS + Seasonal Mod for Cd, Mn, Zn and SSE for Cd.
     - Commission recognized the many unknowns and uncertainties in analysis of source loadings in 3a.
     - Encouraged the continuation of characterization efforts to determine unknown sources of loading
  3. Aquatic Life Indicator Goal
     - Brook Trout: TMDL Target- “Enhancement of existing brook trout fishery”

Priority 2-Howardsville Area

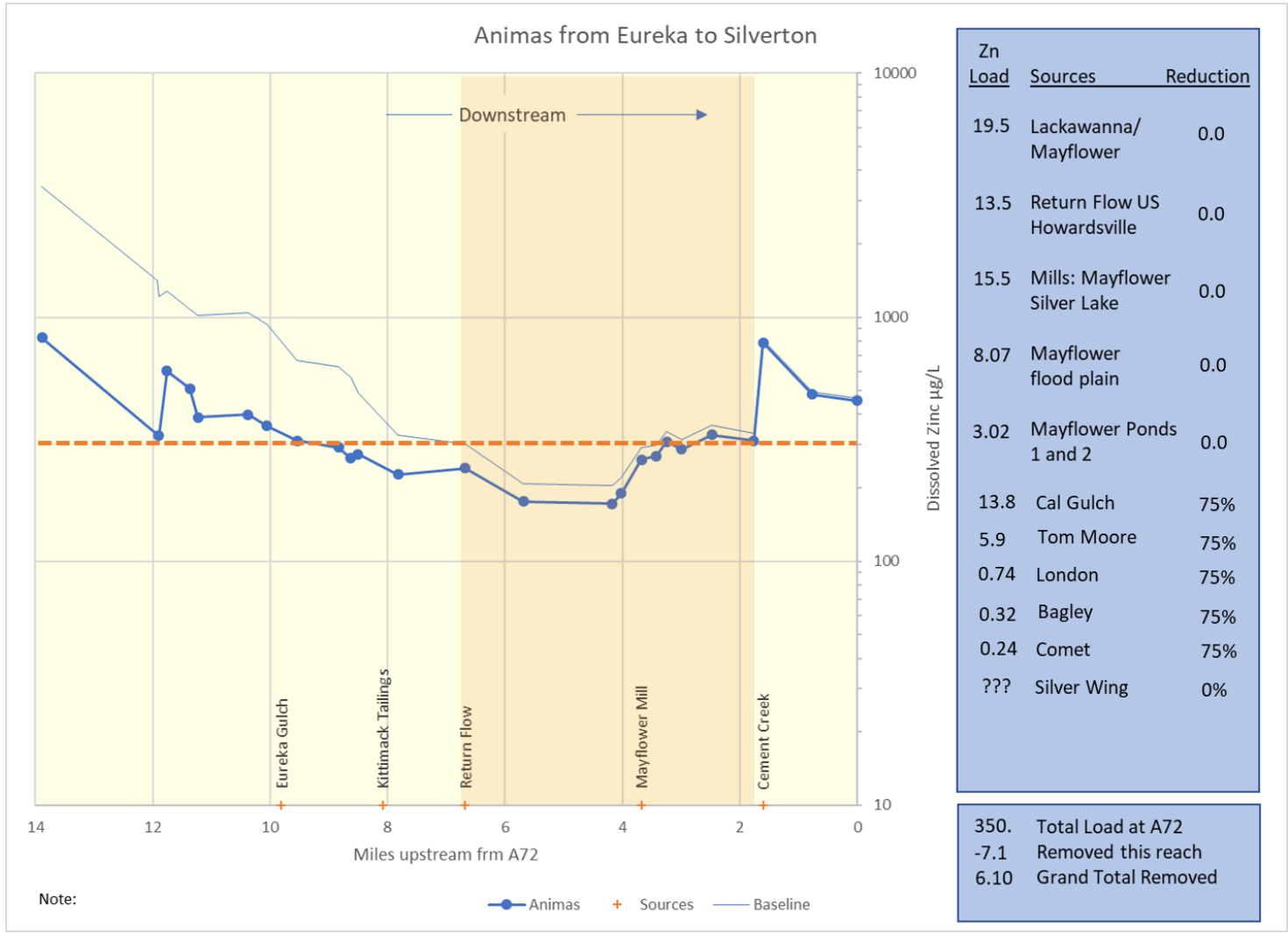
Goal-Improve Water Quality

- Source Areas
  1. California Gulch (77 lbs Zn /day)
     - Columbus Mine (Adit Load ~0.5 lbs Zn/day , Reach loads 20 lbs Zn /day)
     - Frisco/Bagley (Reach loads ~6 lbs/day)
     - Vermillion?
  2. Mainstem Animas
     - Silver Wing (Reach Load 11 lbs/day)
     - Tom Moore (Reach Load 23.6 lbs/day)
  3. Pride of the West Mill (Reach Load ~10 lbs/day)
  4. Mayflower (45-66 lbs/day)



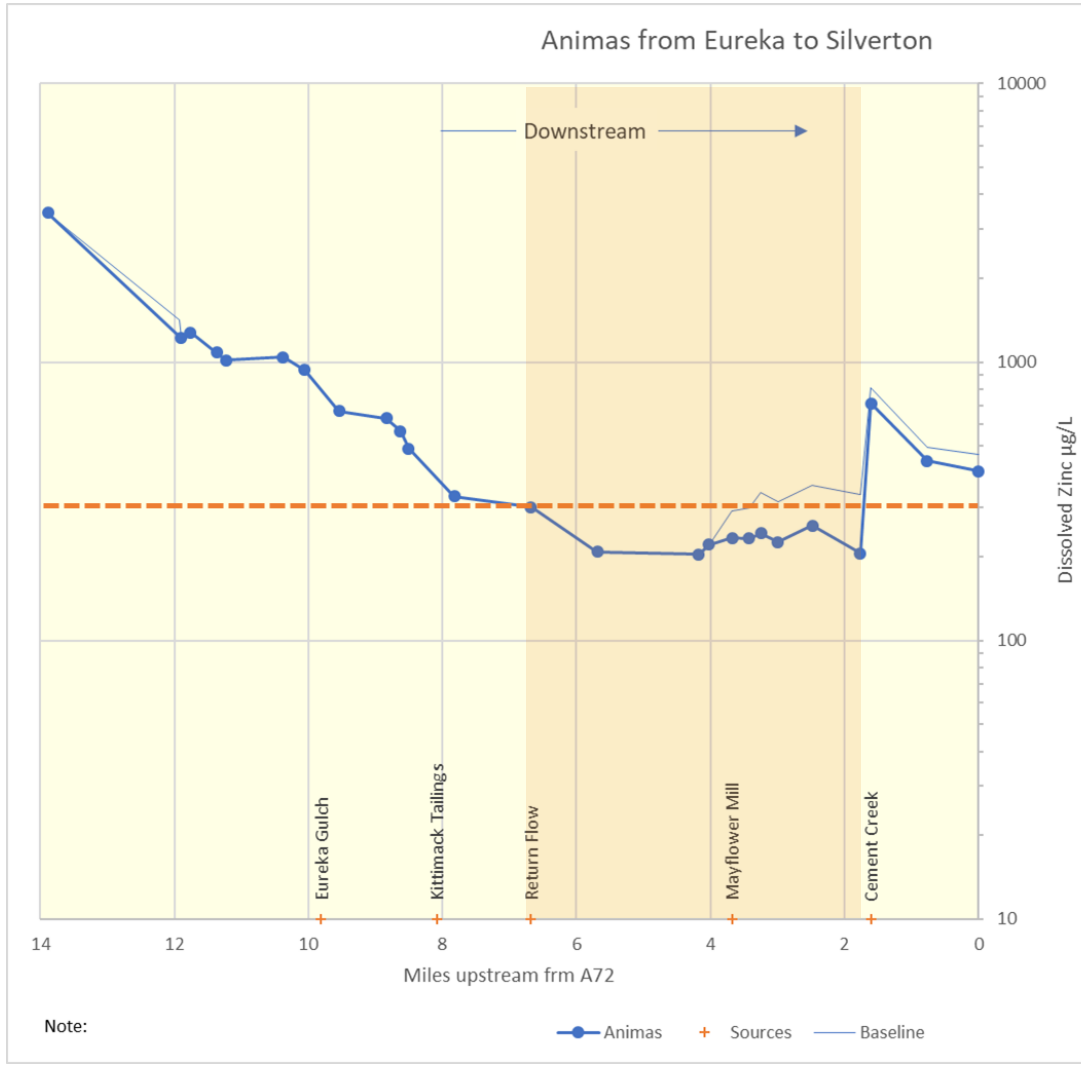
Zn Load	Sources	Reduction
19.5	Lackawanna/ Mayflower	0.0
13.5	Return Flow US Howardsville	0.0
15.5	Mills: Mayflower Silver Lake	0.0
8.07	Mayflower flood plain	0.0
3.02	Mayflower Ponds 1 and 2	0.0
77.2	Cal Gulch	0.0
23.6	Tom Moore	0.0
3.0	London	0.0
1.3	Bagley	0.0
1.0	Comet	0.0
???	Silver Wing	0.0

350.	Total Load at A72
0.0	Removed this reach
0.00	Grand Total Removed



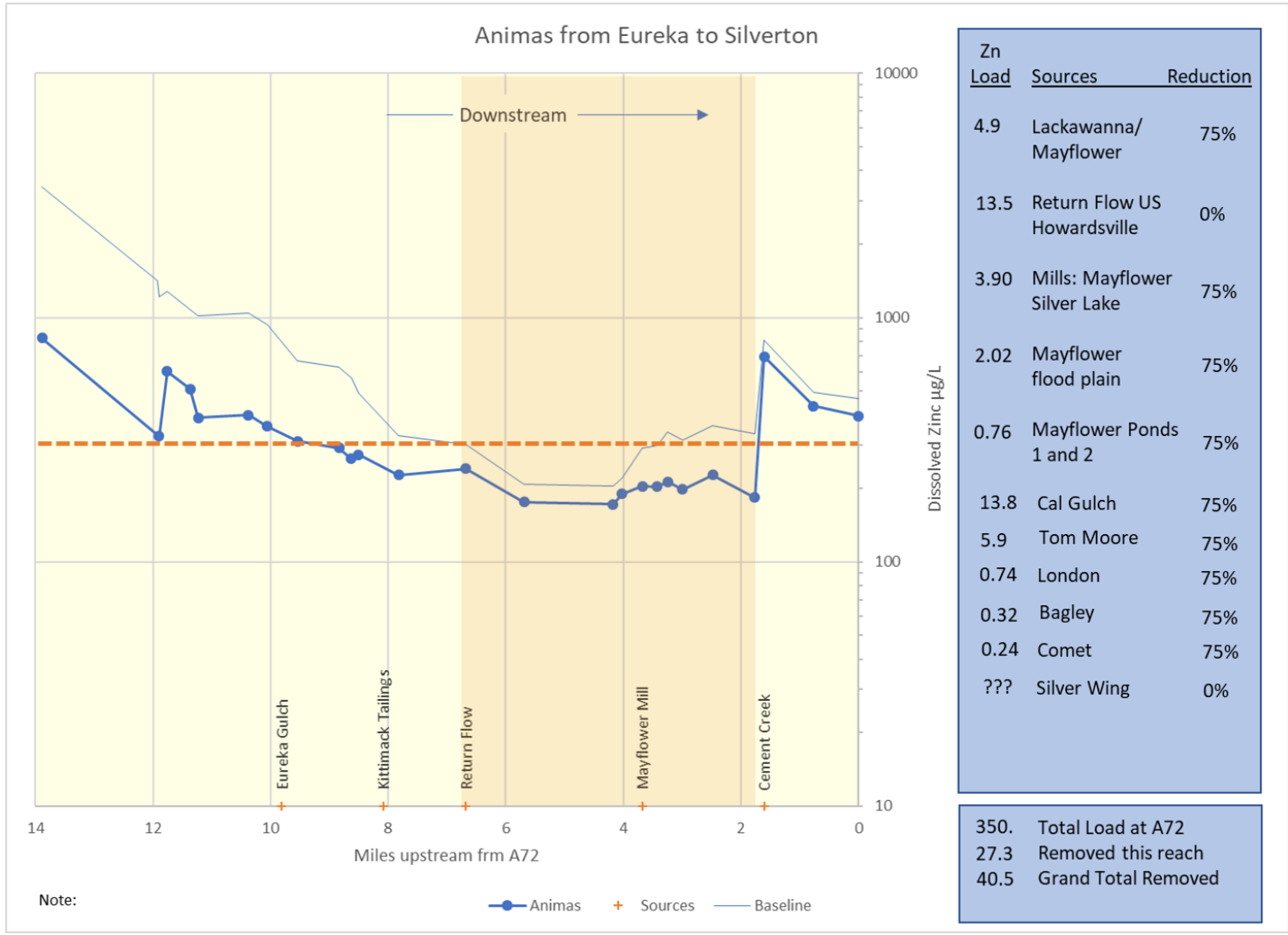
Zn Load	Sources	Reduction
19.5	Lackawanna/ Mayflower	0.0
13.5	Return Flow US Howardsville	0.0
15.5	Mills: Mayflower Silver Lake	0.0
8.07	Mayflower flood plain	0.0
3.02	Mayflower Ponds 1 and 2	0.0
13.8	Cal Gulch	75%
5.9	Tom Moore	75%
0.74	London	75%
0.32	Bagley	75%
0.24	Comet	75%
???	Silver Wing	0%

350.	Total Load at A72
-7.1	Removed this reach
6.10	Grand Total Removed



Zn Load	Sources	Reduction
4.9	Lackawanna/ Mayflower	75%
13.5	Return Flow US Howardsville	0.0
3.90	Mills: Mayflower Silver Lake	75%
2.02	Mayflower flood plain	75%
0.76	Mayflower Ponds 1 and 2	75%
77.2	Cal Gulch	0.0
23.6	Tom Moore	0.0
3.0	London	0.0
1.3	Bagley	0.0
1.0	Comet	0.0
???	Silver Wing	0.0

350.	Total Load at A72
34.4	Removed this reach
34.4	Grand Total Removed



Zn Load	Sources	Reduction
4.9	Lackawanna/ Mayflower	75%
13.5	Return Flow US Howardsville	0%
3.90	Mills: Mayflower Silver Lake	75%
2.02	Mayflower flood plain	75%
0.76	Mayflower Ponds 1 and 2	75%
13.8	Cal Gulch	75%
5.9	Tom Moore	75%
0.74	London	75%
0.32	Bagley	75%
0.24	Comet	75%
???	Silver Wing	0%

350.	Total Load at A72
27.3	Removed this reach
40.5	Grand Total Removed

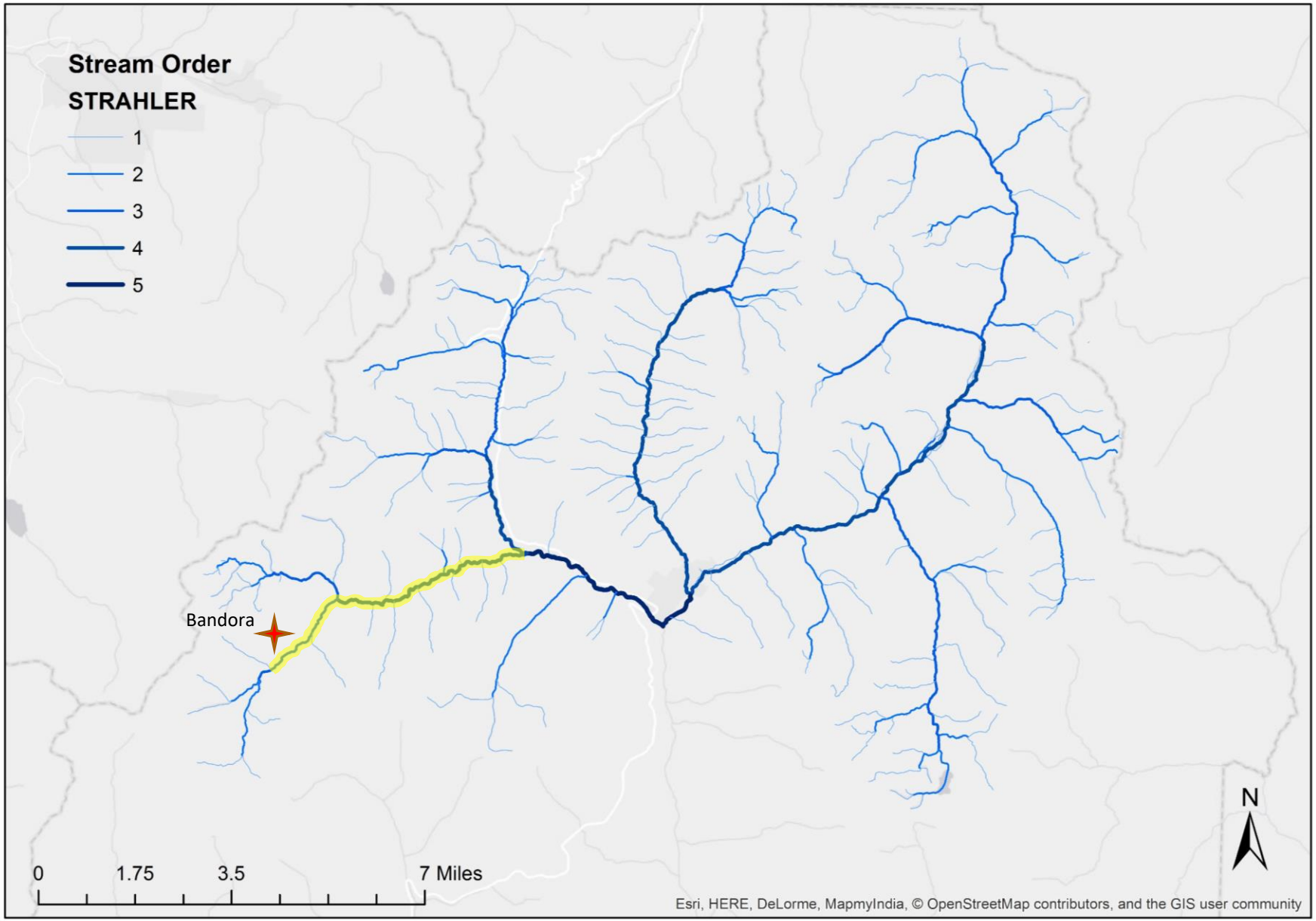
Priority 2-Howardsville Area (Cont.)

Goal-Improve Water Quality

- Data Gaps
  1. Reach Loads Don't Match Mine Loads (Bagley, Columbus, Vermillion)
  2. Silver Wing (Limited Adit Data)
  3. Tom Moore (Limited Data)
  4. Pride of the West Mill (Limited Data, Still Draining?, Confirm Loading)
  5. Mayflower
  6. South Fork Eureka
- Background Needs
  1. Confirm Reach Loads in California Gulch are Anthropogenic
  2. Confirm Vermillion is Not Loading

Priority 3

- South Fork of Mineral Creek from headwaters to mouth
- Water quality is relatively good already
- A few metal loading mines remain, including:
  - Bandora
- Fishery has been stable for a while in this reach
  - Brook trout- abundant
  - Rainbow trout- stocked
  - Cutthroat trout- unknown



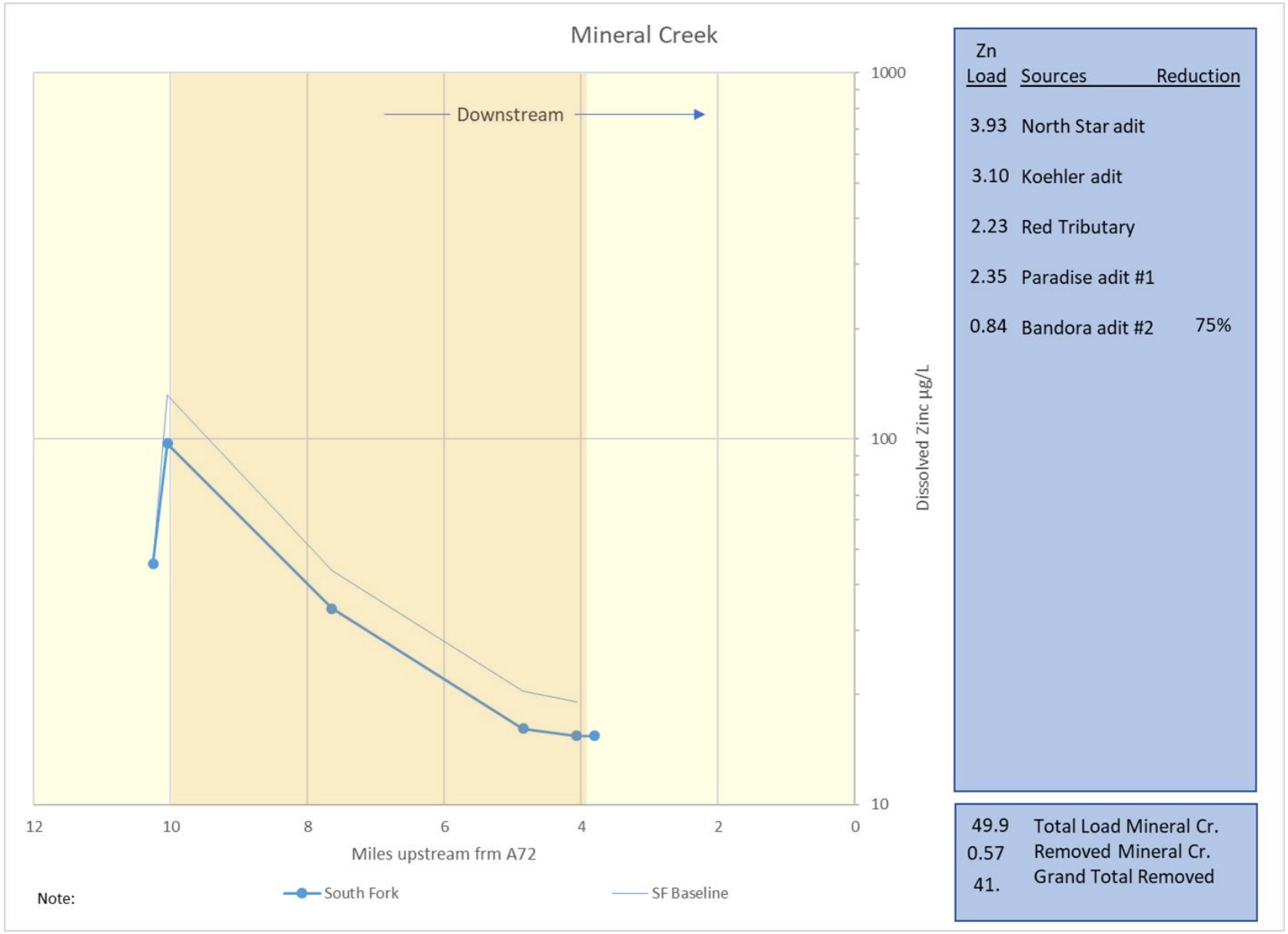
Priority 3-South Fork Mineral Creek

Goal-Improve Water Quality

- Current WQ Standards
  1. Segment 6; South Fork Mineral; *Aquatic Life Cold 1*
  2. TVS + SSE for Cd.
- Source Areas
  1. Bandora (3.35 lbs Zn/day)
  2. Upstream? (126 lb Al/day & low pH)

Priority 3

- Loading reduction of 75% at these mines:
  - Bandora
- Zinc concentrations in Priority Reach #4 predicted to be reduced from ~40 ppb to ~25 ppb
- Good brook trout population already in this reach
- Other metals are likely more problematic than zinc (Al, Cd)



Zn Load	Sources	Reduction
3.93	North Star adit	
3.10	Koehler adit	
2.23	Red Tributary	
2.35	Paradise adit #1	
0.84	Bandora adit #2	75%

49.9	Total Load Mineral Cr.
0.57	Removed Mineral Cr.
41.	Grand Total Removed

Priority 3-South Mineral Creek (Cont.)

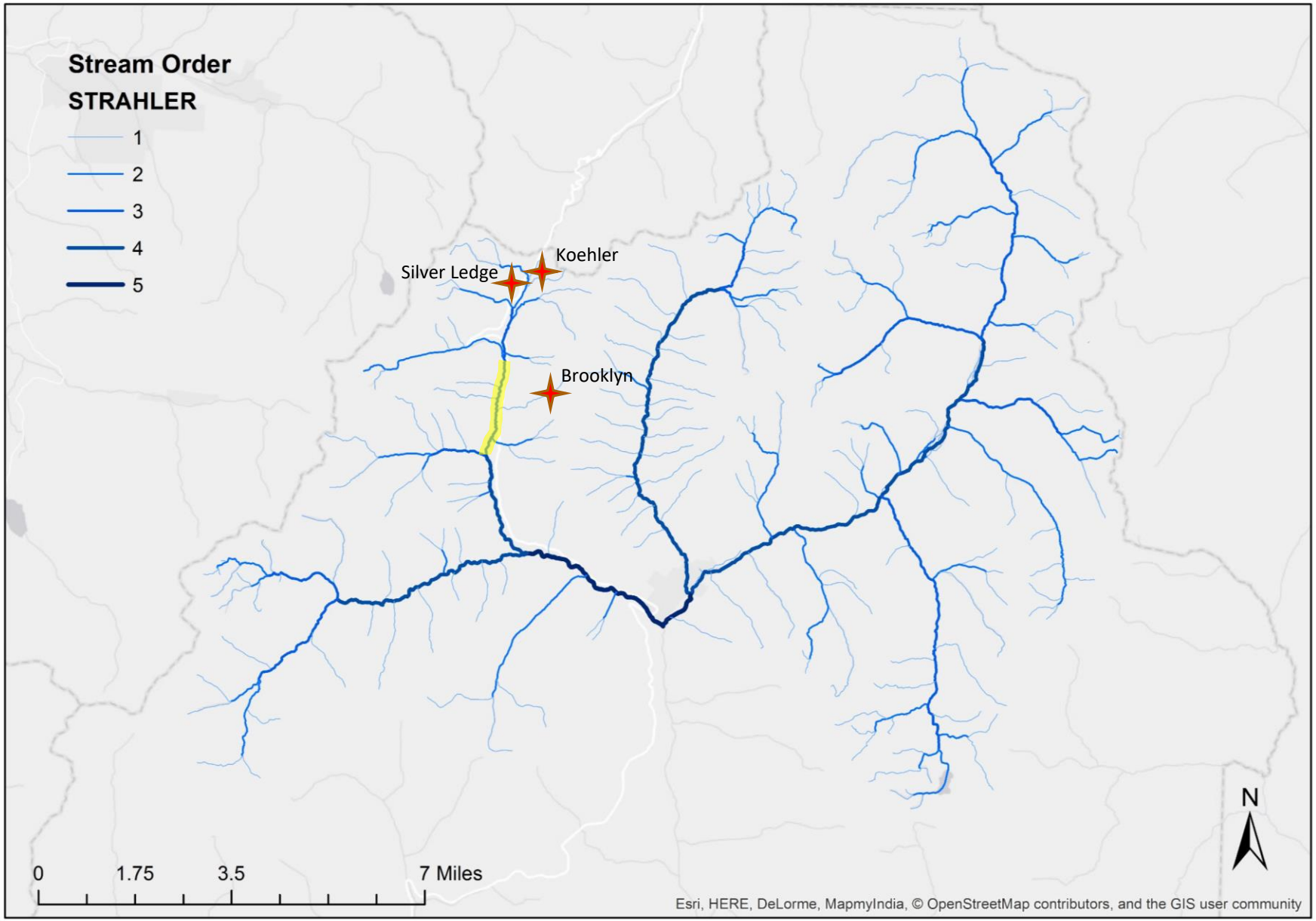
Goal-Improve Water Quality

- Data Gaps
  1. High Variability in Bandora Loading Estimates.
  2. Increase Resolution of Risk Evaluation.
  3. Upstream sources?
  4. Current Status of Fishery

- Background Needs
  1. Upstream sources?

Priority 4

- Mineral Creek between Mill Creek and Middle Fork Mineral Creek
- Significant improvement in water quality has resulted from actions of stakeholders
- Several metal loading mines remain, including:
  - Koehler
  - Silver Ledge
  - Brooklyn
- Brook trout found in this reach in 2016 (for the first time ever)



Priority 4-Upper Mineral Creek

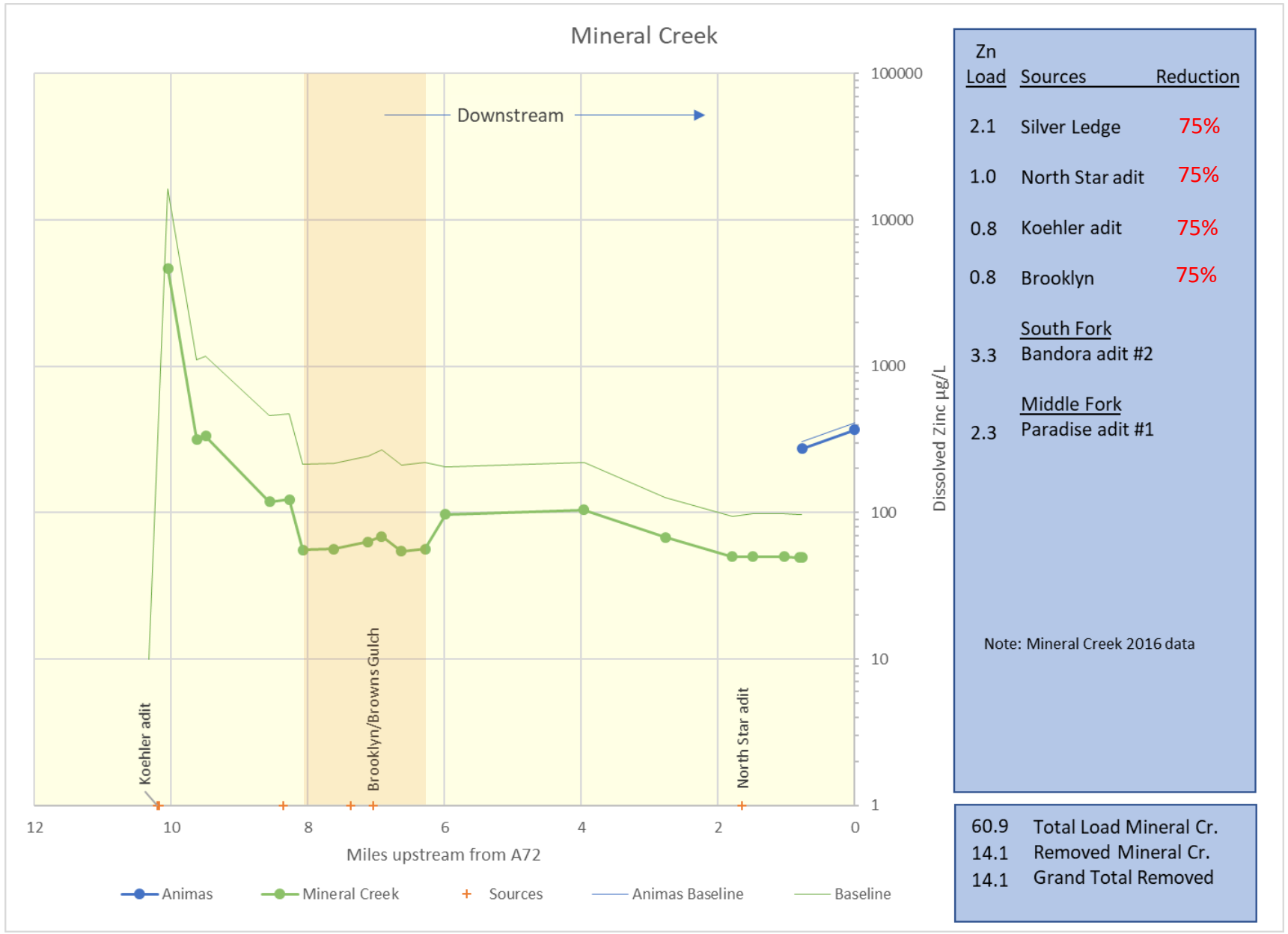
Goal-Improve Water Quality

- Current WQ Standards
  1. Segment 8 Source to Above South Fork: *Agriculture, Recreation E.*
     - No Acute Stds. Maintain Ambient Conditions to Protect Animas.

- Source Areas
  1. Koehler (3 lb Zn/day)
  2. Silver Ledge (5 lb Zn /day reach load)

Priority 4

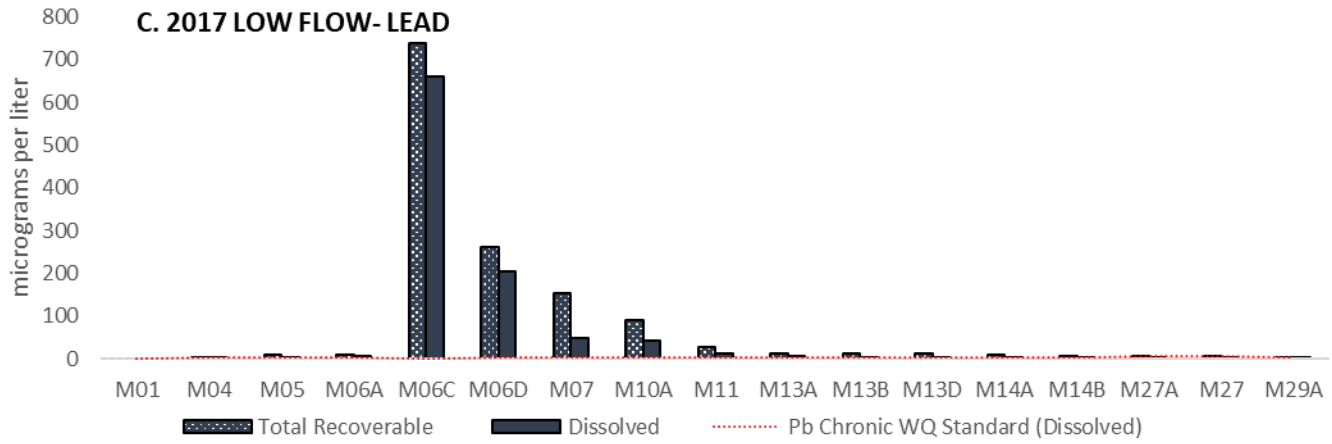
- Loading reduction of 75% at these mines:
  - Silver Ledge
  - Koehler
  - Brooklyn
- Zinc concentrations in Priority Reach #4 predicted to be reduced from ~200 ppb to ~60 ppb
- Marginal brook trout population already in this reach
- Other metals are likely ecologically limiting (Pb, As)

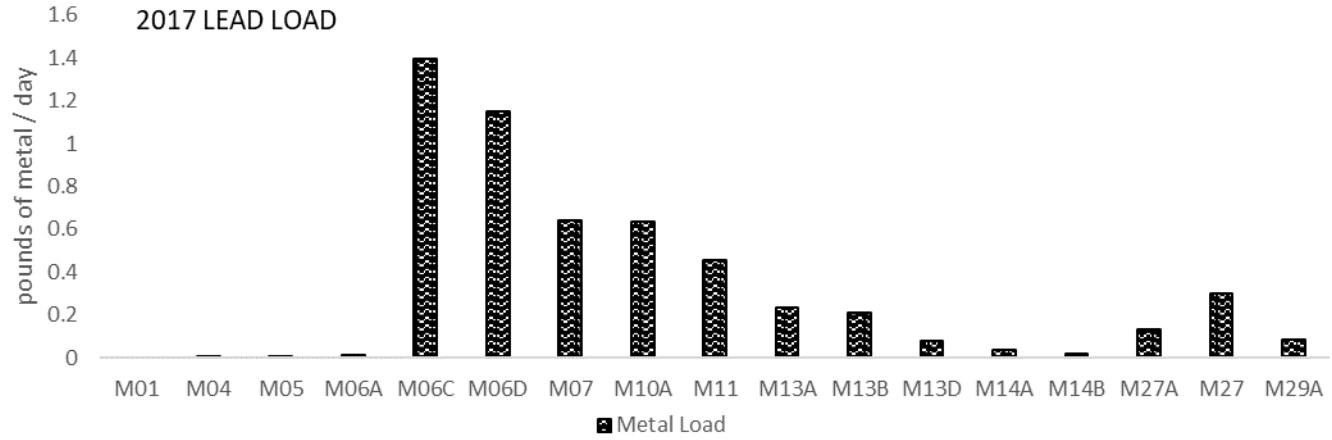


Zn Load	Sources	Reduction
2.1	Silver Ledge	75%
1.0	North Star adit	75%
0.8	Koehler adit	75%
0.8	Brooklyn	75%
	South Fork	
3.3	Bandora adit #2	
	Middle Fork	
2.3	Paradise adit #1	

Note: Mineral Creek 2016 data

60.9	Total Load Mineral Cr.
14.1	Removed Mineral Cr.
14.1	Grand Total Removed





Lead: PRIORITY REACH #4

Priority 4-Upper Mineral Creek (Cont.)

Goal-Improve Water Quality

- Data Gaps
  1. Complicated Area
  2. Silver Ledge Limited Data. (Porphyry Gulch, Big Horn Creek?)
  3. Status of Existing Fishery
     - Is the brook trout fishery in the mainstem resident or coming in from Mill Creek?

- Background Needs
  1. Porphyry Gulch, Big Horn Gulch?
  2. Unnamed tributary near bottom of EU3

Questions

Photo Credit Andrew Todd